4-1931

Circular No. 93 - Better Sugar-Beet Culture for Utah

George Stewart

D. W. Pittman

CIRCULAR NO. 93 APRIL, 1931

Better Sugar-Beet Culture For Utah

GEORGE STEWART AND D. W. PITTMAN

Utah Agricultural Experiment Station

Utah State Agricultural College

LOGAN, UTAH

Better Sugar-Beet Culture For Utah[1]

By George Stewart and D. W. Pittman[2]

Utah was one of the first states to begin sugar-beet growing. The industry grew rapidly, favored by the climate, by the naturally productive soils, by the freedom from pests, and by the system of intensive irrigation agriculture. California and Utah were among the leading beet-producing states at the time of the World War, and under the stimulus of high prices they remained so until the great depression of 1920. After that, the frequent occurrence of curly-top and the rapid spread of nematode, together with the low price resulting from increased cane sugar production in the tropics and from other causes combined to cause a decline in the importance of sugar-beets.

In Table 1 are given the data for total production of sugar-beets by states in 1916, 1920, 1925, and 1930. A study of this table shows that Colorado and Nebraska have increased greatly but that the other states reached a peak about 1920 and then declined, save California whose peak was in 1916.

TABLE 1.—TOTAL PRODUCTION OF SUGAR-BEETS FOR THE YEARS 1916, 1920, 1925, AND 1930 IN ORDER OF TOTAL PRODUCTION IN 1930

State	Beet Roots Sliced (Tons)			
	1916	1920	1925	1930
Colorado	1,933,000	2,370,000	2,403,000*	2,880,000
Nebraska	404,000	707,000	876,000	1,062,000
Idaho	331,000	498,000	470,000	565,000
Utah	708,000	1,304,000	990,000†	564,000
California	1,462,000	1,037,000	783,000*	544,000
Wyoming and Montana	(1)	(1)	604,000	427,000
Michigan	503,000	1,259,000	1,005,000	287,000
Ohio	138,000	451,000	337,000	185,000
Other states	380,000	718,000	466,000	659,000

(1) Listed with "Other States."
*1924 crop. The 1925 crop was unusually low.
†About 20 per cent above normal; Utah had a phenomenal crop in 1925. The 1924 crop was 540,000 and the 1926 crop 391,000. Both of these were unusually poor crops. The average for 1924 and 1925 was 765,000 and would be about what 1925 would have produced in a normal year.

Utah increased from 708,000 tons in 1916 to 1,304,000 in 1920 and then decreased, until by 1930 there were but 564,000 tons. The 990,000 tons grown in Utah in 1925 is probably 20 per cent higher than any ordinary season would have produced. Utah's average acre-yield was 15.4 tons in 1925 as compared to 7 tons for 1924 and 8.1 tons for 1926 and in a normal year a yield of about 12 tons.

Acknowledgements: The writers are glad to express their appreciation to Professor D. C. Tingey and Mr. Wesley Keller for valuable suggestions.
[1]Contribution from Department of Agronomy, Utah Agricultural Experiment Station.
[2]Agronomist and Associate Agronomist, respectively.
Publication authorized by Director, April 1, 1931.

This decrease has been in part due to poor acre-yields, resulting largely from too-constant cropping to beets, from lack of adjustment between livestock and beet-growing, and from injury by nematode and leafhopper. The economic uncertainty of price and the competition of tropic-grown cane sugar have cut deep. In spite of these handicaps, in 1927, 1928, 1929, and 1930, about 12 to 15 per cent of Utah's total crop value has come from sugar-beets which occupied only 5 per cent of the land. In comparison, alfalfa which produced 32 per cent of the crop income occupied 45 per cent of the total crop area, while small grains produced 22 per cent of the income from 31 per cent of the area. Acre for acre, the income from sugar-beet land is more than three times as great as from alfalfa or grain. Potatoes, truck crops, and fruit compare favorably with beets in the ratio of income to area. Since Utah will probably intensify production on the best grade of crop lands, sugar-beets fit well into a combined system of livestock, alfalfa, grain, and cultivated crops.

Just what sensible soil treatment may accomplish is shown by the unfavorable years of 1924 and 1926. Due to the combined effects of poor soil treatment, drought, leafhopper, rootrot, and nematode, the average acre-yield of beets for Utah in 1924 was 7.01 tons. About 10 per cent of the growers who had practised proper farming methods obtained nearly full yields. At the Experimental Farm at North Logan (Greenville), plats that had received moderately good soil treatment for the previous few years, according to plats named at random, yielded 18.8, 10.2, 15.8, 17.2, 19.4, and 16.3 tons, respectively, while heavily manured beets yielded 22.5 and 27.3 tons. Immediately adjacent were other plats neglected in much the same way as were large areas of the farming land, from which typical acre-yields in random order were 2.71, 3.95, 2.31, 1.03, and 4.45 tons. The 1926 results were practically identical.

An examination of the methods which produced satisfactory yields with reasonable effort in 1924 and 1926 may be of interest. Factors in production, such as soil treatment, irrigation, and cultural practices are considered in order, followed by a few suggestions regarding preventable losses during harvest.

FACTORS IN PRODUCTION

As with other crops, there are a number of major factors which influence a successful production of sugar-beets. The major factors in sugar-beet production are: (1) Climate, (2) soil and soil treatment, (3) labor-supply, (4) culture, (5) irrigation, and (6) pests.

Climate

In the oceanic climate of western Europe the relatively long frost-free period in the fall permits a continuation of growth of beets in this season of the year; but in interior climates, such as western United States, the early frosts are counterbalanced by the fact that a moderate frost, such as kills potatoes and corn, may still allow the sugar-beets to grow. It is thought by many of the best trained agriculturists that such a fall frost helps to increase the sugar content of the beets during the subsequent two or three weeks.

Excessively rainy climates, especially if accompanied by hot, humid weather, are unfavorable to beets, due largely to the fact that certain diseases are particularly favored with respect to bright, clear weather and to seasons that are at least moderately favorable so far as fall frosts are concerned.

Soil and Soil Treatment

Sugar-beets are not nearly as sensitive to the kind of soil in which they are grown. Almost all soil types, except those that are extremely porous and those that are extremely compact, may be put in proper condition for sugar-beets. Medium soils, especially those that are verging toward silt loams, tend to produce a high yield over a long period of years; however, some of the most productive soils in the entire sugar-beet area are distinctly sandy and consequently porous, but often with a clay subsoil. A soil, the body of which is mainly gravel without any considerable proportion of fine material, is distinctly unfavorable on account of its inability to hold soil moisture in sufficient quantity and for a sufficient length of time. Excessively compact soils cause difficulties in securing a stand and in hand operations such as thinning. Surprisingly good yields may be obtained from naturally compact soils, provided intelligent care is given for a few years to rotation, manuring, and tillage, including proper time and type of plowing.

Labor-Supply

During thinning and harvesting extra hand labor is required and some adequate source of supply must be available. Where the areas produced by individual farmers are 40 to 50 acres or more, it is usually necessary that special sources of imported labor be provided. Formerly, Japanese labor was much used, being imported by contractors. More recently this has been replaced by Mexican labor brought in either by the contract system or by the sugar-beet companies themselves. The great necessity of this sort of labor makes such importations desirable from an economic standpoint. Unfortunately, this economic advantage is offset to a considerable extent by certain social disadvantages that come from importing uneducated labor into rather stabilized communities where most of the farmers and business men are well-educated and, in the main, have a considerably higher standard of living than do imported laborers.

In many agricultural communities in Utah, where the acreage grown by individual farmers is 5 to 30 acres, boys (and sometimes girls) and men, from neighboring towns and villages furnish a much more desirable sort of hand labor. The boys in some communities, organized into groups (sometimes through the local agency of Boy Scouts), have handled thinning successfully. A drawback to this method is that boy labor from the non-agricultural towns is often not satisfactory. In addition, at the time of harvest the boys are usually in school, and unless special provisions are made for a "beet holiday" there is a scarcity of harvest labor. Under favorable conditions the larger boys, and the stronger small ones who are skilled, can top beets successfully. However, when beets are large, men are better adapted for beet-topping. Loading is nearly always too heavy for any except the larger and stronger boys. Men and boys who have not done farm work for a considerable time but have devoted their attention to city industries and city occupations are usually unfitted for beet-topping both through lack of skill and also through lack of interest in beet growing.

Culture

Proper culture of sugar-beets involves a long series of operations such as seeding, cultivating, thinning, weeding, and irrigation. These operations are so highly important that it is necessary to give them fairly complete treatment. Cultural operations are later discussed in considerable detail.

Irrigation

Irrigation is so critically important for those sections using irrigation water that it is discussed at length subsequently. The supply of water, the regularity with which it may be obtained, the knowledge of how to handle it, and also crop requirements deserve detailed consideration. However, in the central part of the United States there are a number of successful sugar-beet growing communities where irrigation is not practiced. It would seem that at present there is a considerable shift from irrigated regions to the central states, such as Minnesota, Iowa, Wisconsin, and perhaps to several other states in the surrounding regions.

Pests and Diseases

In the interior mountain region and in the Pacific Coast region, pests and diseases have been so extremely injurious that the importance of sugar-beet growing has diminished rather than increased.

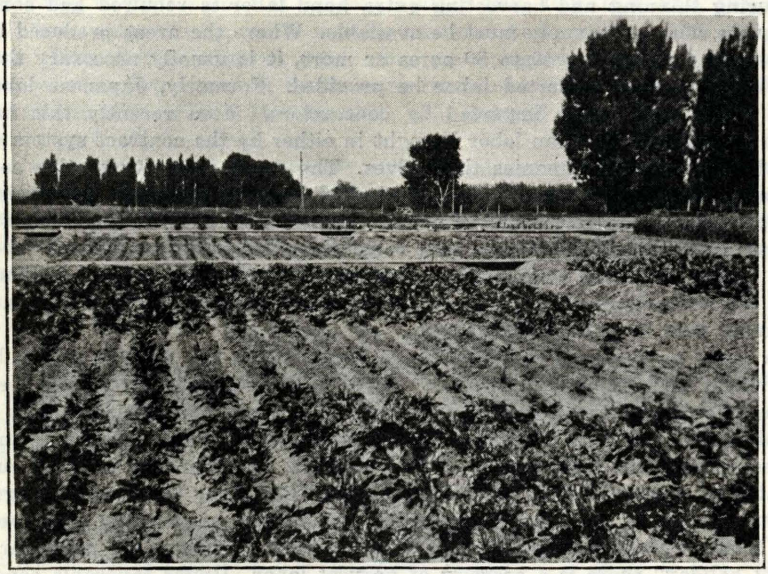

Figure 1—A "nematode spot" in a fairly good plat of beets.

In the early history of sugar-beet growing in the West, for many years lands were constantly cropped to beets, which practice tended to encourage the spread and to increase the intensity of infestation of sugar-beet nematode. Although a cultural method of escaping the major ravages of this pest has been found, for a time at least, it became so serious as greatly to depress sugar-beet cultivation. Nematode injury is not limited to any particular climate or soil condition.

On the other hand, sugar-beet leafhoppers which spread "curly-top" disease of sugar-beets are limited at present to that part of the country west of the main chain of the Rocky Mountains. The leafhopper, or "white-fly" as it is commonly called, is a small insect much like a grasshopper but only about ⅛ of an inch long. It feeds during a large part of the year on native or on introduced desert vegetation, such as Russian thistle. During the spring, about the time beets are ready to be thinned the leafhopper migrates either short or long distances and lights on the young beet. Recent investigations have proved that the same virus transmitted by the sugar-beet hopper produces "western yellow blight" of tomatoes as well as a similar, though fortunately a less injurious, disease of beans. Melons and squash are also affected to a lesser extent.

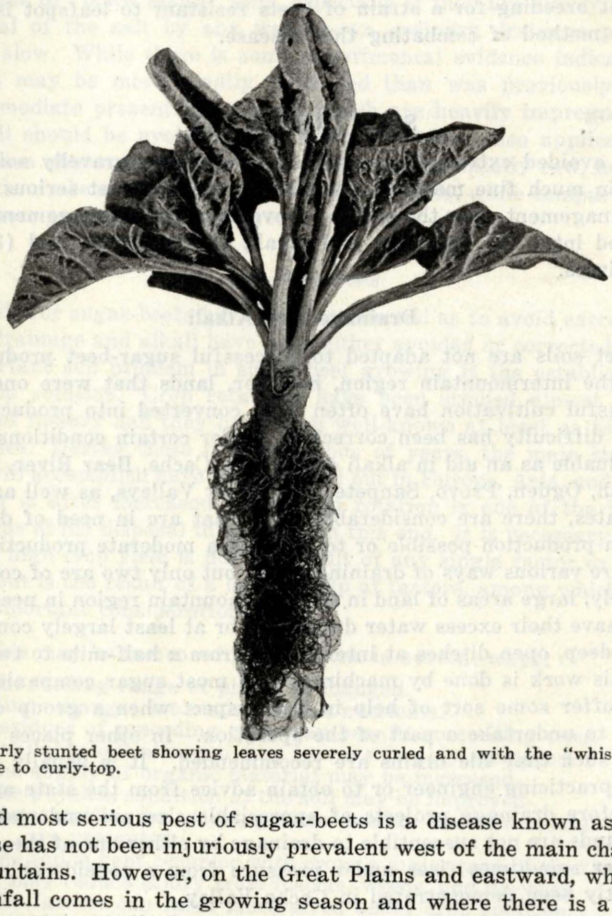

Figure 2—Early stunted beet showing leaves severely curled and with the "whiskered" root due to curly-top.

The third most serious pest of sugar-beets is a disease known as leafspot. This disease has not been injuriously prevalent west of the main chain of the Rocky Mountains. However, on the Great Plains and eastward, where much of the rainfall comes in the growing season and where there is a tendency for high humidity during the hot weather, this fungus spreads rapidly and in some cases almost entirely destroys the top growth of the beets, though usually only partial destruction results.

There are still other diseases, or groups of diseases, variously known as "blight" or "root rot" which are particularly prevalent in dry years and on unmanured soils that occasionally cause serious injury to the beet fields. Proper manuring or fertilization, irrigation, and cultural practices, as explained later, is the remedy.

From an agricultural standpoint it is safe to say that these four—sugar-beet nematode, sugar-beet leafhopper, blight or root rot, and the leafspot of sugar-beets—constitute in one region or another some of our major sugar-beet problems. It might be well at this time to anticipate the more detailed discussion by saying that a proper crop rotation assists greatly in combating nematode. Soil kept in the highest productivity with beets seeded early, overcomes in a measure the effects of the leafhopper, but it is generally accepted that there is most urgent necessity for breeding a strain of sugar-beets that will be resistant to the virus carried by this insect. It is also believed that breeding for a strain of beets resistant to leafspot is the most promising method of combating that disease.

SOIL TREATMENT

Having avoided extremely compact soils and also gravelly soils that do not contain much fine material, the farmer has his most serious soil problem in management. For the sake of convenience soil management problems are divided into: (1) Drainage and alkali, (2) rotations, and (3) manure and fertilizers.

Drainage and Alkali

Over-wet soils are not adapted to successful sugar-beet production. In much of the intermountain region, however, lands that were once too wet for successful cultivation have often been converted into productive lands, when this difficulty has been corrected. Under certain conditions, drainage is also valuable as an aid in alkali control. In Cache, Bear River, Great Salt Lake, Utah, Ogden, Provo, Sanpete, and Sevier Valleys, as well as in neighboring states, there are considerable areas that are in need of drainage to make high production possible or to increase a moderate production.

There are various ways of draining lands, but only two are of consequence. Fortunately, large areas of land in the intermountain region in need of drainage may have their excess water drawn off, or at least largely controlled, by means of deep, open ditches at intervals of from a half-mile to two or three miles. This work is done by machinery and most sugar companies are prepared to offer some sort of help in this respect when a group of farmers is willing to undertake a part of the operation. In other places soil conditions are such that tile drains are recommended. It is usually wisdom to consult a practicing engineer or to obtain advice from the state agricultural college before drainage projects of appreciable size are undertaken. However, all lands are not susceptible to drainage by either one of these methods, since water sometimes rises under pressure from a considerable depth, as has recently been demonstrated in Cache Valley.

Sugar-beets are somewhat more resistant to alkali than are most of the ordinary farm crops. The degree of their ability to resist alkali, however, should not be overestimated. Strong alkali injures sugar-beets severely and quickly. When land is faintly alkaline and contains just enough salt to cause injury to potatoes, to the grain crops, and to truck crops, sugar-beets will frequently thrive. The danger, however, of an increasing amount of salt in the soil due to seepage is so great that precaution is necessary to prevent the accumulation of alkali and especially to remove that which is already present. The most successful method of accomplishing this is by some dependable system of drainage.

There are appreciable areas that contain too much salt even though the soils are not subjected to excess water. It is usually necessary on this type of soil to supply fresh water in sufficient quantities to cause leaching through the drains. In time the ordinary white alkali (sodium sulfate) and common salt (sodium chloride) will be removed to such an extent that farm operations may begin.

In the case of "black alkali" soils, especially if they are clayey in nature, the removal of the salt by any well-known ordinary drainage practice is extremely slow. While there is some experimental evidence indicating that such lands may be more readily reclaimed than was previously thought, for the immediate present those lands which are heavily impregnated with black alkali should be avoided. This recommendation also applies to those lands that are almost entirely gravel or that are essentially raw, heavy clay. Gravel lands are better adapted to fruits or to alfalfa, while compact soils are probably more productive as pasture.

Crop Rotations

After soils for sugar-beets have been so selected as to avoid extreme types and after drainage and alkali have been either avoided or corrected, the next most important soil problem in sugar-beet growing is the establishment of a good crop rotation. Crop rotations have been studied almost from the beginning of history and they have been well-known at least as far back as Roman times. During these two thousands of years, the main things that rotations will accomplish have been worked out in Europe, Asia, and America. The farmer is after increased yields, and rotation is one of the important means he has at his disposal to accomplish this end. It is necessary to recognize that a high crop yield is not the result of any single factor or small set of factors but is the result of a large group of factors, among which rotation deserves important consideration.

Crop yields may be increased by rotations in several ways:

1. The feeding range of plants is changed.
2. Minor changes are made in plant nutrients.
3. Residues of preceding crop may benefit succeeding ones.
4. Available soil nitrogen may be considerably increased.
5. The supply of organic material may be increased.
6. The physical condition of the soil may be improved.
7. Opportunities for utilizing farm manure and commercial fertilizers are presented.
8. The soil is kept occupied with crops a major part of the time.
9. It may reduce injury from insects, weeds, and diseases.
10. The farmer can farm more acres under crop rotation.
11. Farm machinery and other equipment may be used more efficiently.
12. Irrigation water may be made to care for more crop acres.
13. The income is more dependable on account of its arising from several sources.

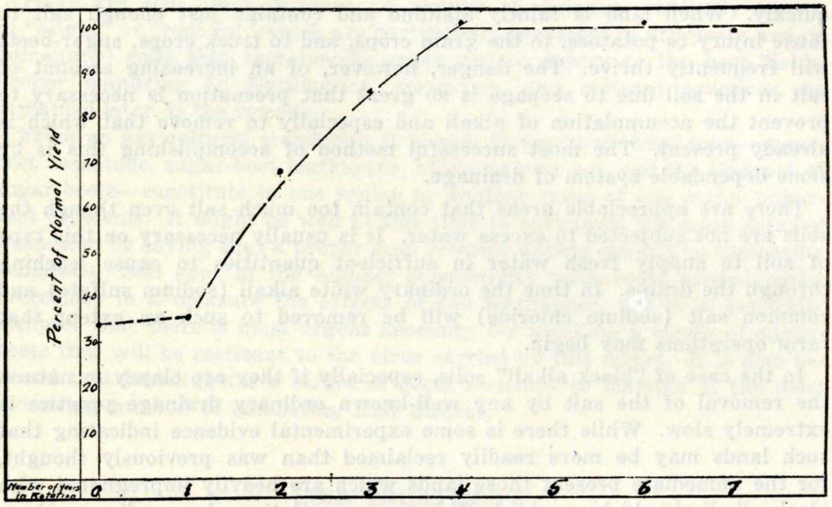

Figure 3—Yield of beets on infested land, expressed in percentage of normal yield when beets had no other crop between successive beet crops and when other crops were grown for one to seven years between beet crops. One year of other crop was without effect, but the yield increased rapidly when other crops were grown two, three, or four years. More than four years was of no further value.

Some of the more important principles to be observed in establishing a good crop rotation are here considered. Although details of arrangement and crops vary with the region, fundamentals differ but little. The basic principles of good crop rotation and diversified farming among other things probably warrant an attempt to accomplish the following:

1. To grow approximately the same acreage of each crop each year.
2. To grow at least one cash crop.
3. To have a hay crop.
4. To have a sod-forming crop that lasts several years.
5. To include a legume.
6. To alternate tilled and non-tilled crops.
7. To alternate deep-rooted and shallow-rooted crops.
8. To arrange crops in such a way as to distribute the seasonal requirements of labor, equipment, irrigation water, and personal supervision.
9. To follow such a sequence of crops as will help to maintain good soil sanitation and at the same time be convenient.
10. To keep livestock.
11. To apply manure to that crop which gives the most profitable response.
12. To be prepared to make use of all by-products in order to avoid waste.

Probably no rotation will fulfill all these requirements, but an attempt should be made to approach them.

In addition the farmer has the problem of adjusting the rotation to his own farm. Just how to make this adjustment depends not only upon farming operations, but upon economic, marketing, and community relations. Two or three rotations that seem to have wide adaptation in Utah and in adjacent regions are as follows:

I—Alfalfa .... 4 or 5 years
Corn or potatoes .... 1 year
Sugar-beets, with manure .... 1 or 2 years
Small grains .... 1 year
(Alfalfa is seeded with the small grain.)

II—On sandy lands, especially, it may be that three years is long enough for alfalfa, and where the land is particularly valuable a truck crop or sugar-beets may be seeded immediately following alfalfa by taking special precautions to prepare a firm mellow seedbed. Recently there has been introduced in Cache Valley a tractor-crowning device which greatly reduces the difficulty in killing alfalfa.

III—Some trucking sections find it necessary to omit the growing of alfalfa altogether. Soil difficulties are usually encountered, however, if all the legumes are omitted from the rotation. In some circumstances it may be that sweet clover for pasture will more adequately take care of this need than will the longer-lived alfalfa.

There are conditions which these three general rotation types will not suit, but slight modifications will perhaps make them adjustable to most conditions.

Manure and Fertilizers

In the main, western soils are deficient in organic matter. On this account it is usually necessary to provide for an ample supply of organic matter, either by means of green manure or of farm manure. Green-manure crops turned under in the fall have not been particularly successful, perhaps on account of the fact that temperatures are too low to permit immediate decay. When the weather is warm and when there is a sufficient water-supply, decomposition is usually active. On this account, green crops turned under in the spring have frequently given more satisfactory results. In parts of Colorado, for example, large acreages of truck crops and of sugar-beets are grown after alfalfa is turned under in the spring when the first crop is some inches high or after alfalfa is turned under in the late summer when the last cutting has on it a considerable green growth.

Better results have been obtained, as indicated by the experiments in Utah, Idaho, Nebraska, and South Dakota, when farm manure is applied, either by its being hauled on the land or by pasturing the animals on sweet clover or other pasture crops with the stubble and manure turned under together. Sometimes grass sod can be made to supply this need, in which case it is usually necessary to grow a small-grain crop, or corn, or potatoes during the first year after breaking.

The chief function of farm manure and of sod is to supply organic matter. In the end, complete decomposition results and the fertilizing elements are added to the soil in a readily available form. Important as the fertilizing elements may be, the indirect effects of organic matter are still more important. Coarse manure and large roots are hindrances to cultivation and to irrigation, but under favorable conditions, these soon decompose into fine particles that mix readily with the soil. Organic matter in such condition is valuable in two distinct ways: (1) By increasing the water-holding capacity and (2) by creating a condition of medium porosity in the soil.

Decaying organic matter absorbs water much as does a sponge. Because many of the particles are hollow, the surface area to which films of water are able to cling is much greater than on solid particles of the same volume.

In addition, organic matter contains a substance called humic acid which has the power of holding many times its own weight of water.

Organic matter also loosens clay soils and renders them porous. It has the opposite effect on coarse sands, in which it binds the soil particles together. Being a good retainer of water, organic matter tends to keep the soil more

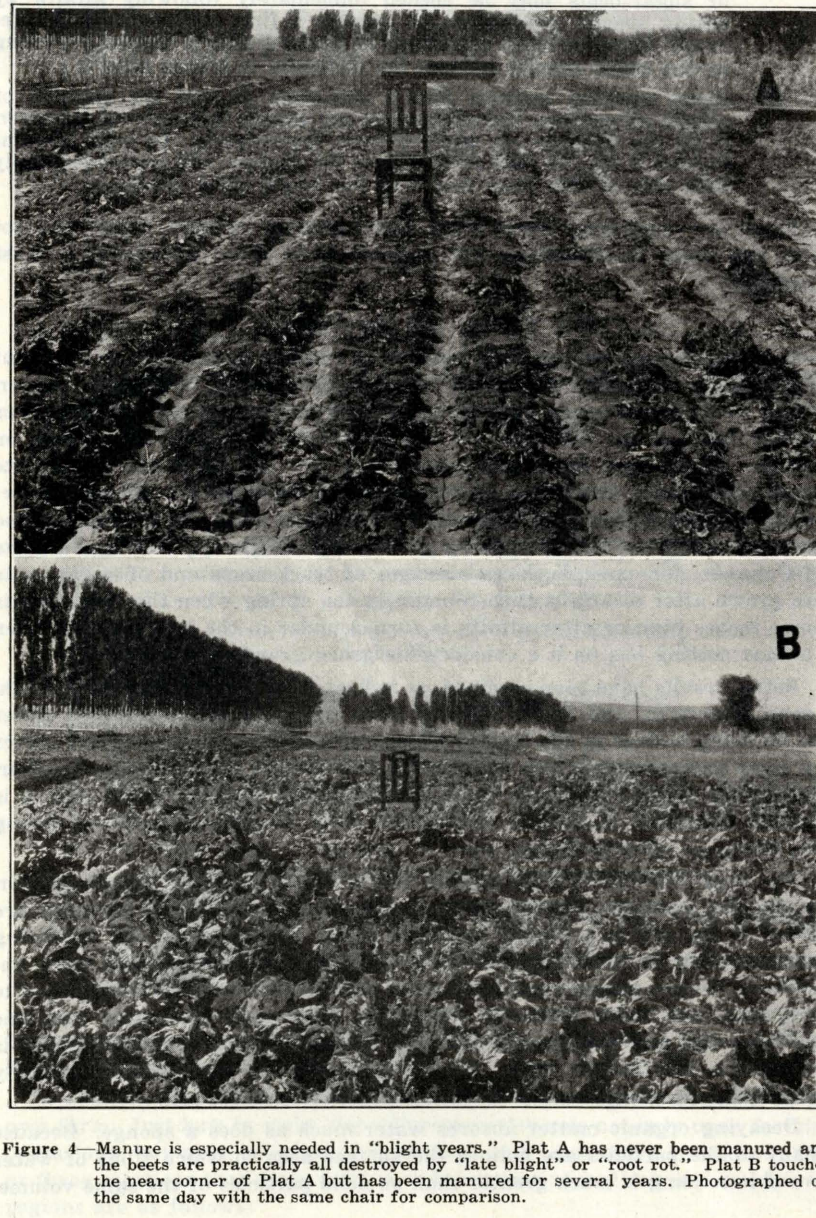

Figure 4—Manure is especially needed in "blight years." Plat A has never been manured and the beets are practically all destroyed by "late blight" or "root rot." Plat B touches the near corner of Plat A but has been manured for several years. Photographed on the same day with the same chair for comparison.

moist. Moderate quantities of soil moisture also tend to cause soil particles to group themselves into granules.

Organic matter consolidates loose soils both by supplying a binding agent and by furnishing a retainer of water. Both a high degree of looseness in clays and a high degree of consolidation in sands increase the water-holding powers of such soils. These conditions also encourage a more desirable aeration and a great uniformity of temperature.

Compact clays have too small pore spaces to hold much available water or to permit the easy exchange of gases between the soil and the atmosphere. Roots and bacteria both need air; oxygen also helps in rendering mineral plant nutrients soluble. Increased moisture and the consolidation of sandy soils moderate the temperature of these soils and thereby decrease evaporation. In heavy soils the increase of pore space encourages a more thorough ventilation. As the water content increases to about medium, the volume of the soil, and hence the pore space, increases. If more water is added, the volume, and consequently the air space, decreases. It is at the point of greatest volume the soils aerate most readily and consequently maintain the most uniform temperatures. Roots can pentrate a soil in this condition more easily and more deeply because air is available at greater depths and because there is less physical resistance from the soil itself. In all respects the soil is then in the most favorable condition for plant growth. When such a desirable soil condition is reached, it is said to hold an "optimum" water content. Actively decaying organic matter tends to bring all soils into this desirable optimum condition.

Farm Manure

When farm manure is available, its manner of application and the quantity to use are both important considerations. Farm manure may be applied to a previous crop such as corn, potatoes, or garden stuff. It may be added as a thin coating after peas or beans, or on alfalfa or grass sod previous to breaking. Another practice that is gaining favor among successful growers is the fall or winter application of manure on fall-plowed land. Turning-under in the fall is preferred, but to apply the manure on the plowed ground in the fall or on the snow at any time during the winter, to be worked into the soil in the spring with a disk or springtooth harrow, is also satisfactory. If the land is not fall-plowed, it is still good practice to apply the manure in the fall or during the winter, even on top of snow. Unless the land is steep and compact, or so badly eroded as to form channels, there will be little loss from the carrying away of manure in the runoff when the snow melts. Frozen ground with snow on it soon thaws, on which account there is little danger from runoff because of frozen ground. If for any reason fall or winter application is not made, the manure should be added at the earliest possible time in the spring.

It is also advisable not to use manure containing much coarse straw or cornstalks for spring application unless no other manure is available. The turning-under of coarse manure just ahead of seeding beets will delay growth. Finally, irrigation and cultivation are more difficult than when the manure is not sufficiently decomposed to be readily incorporated with the soil.

Applications of moderate quantities of manure have given more economic results for all ordinary crops than have either extremely light or extremely heavy applications. The manure should be scattered over the land at the time it is being hauled. Manure spreaders are more efficient than hand labor. Making small piles to be scattered at another operation is wasteful of labor. Since this practice prevents uniform distribution, it is also wasteful of manure. Much of the plant-nutrient material is leached into the soil directly beneath the pile, leaving only the resistant remnants to be scattered.

Careful studies through many years at the Utah Agricultural Experiment Station have brought out clearly the great value of farm manure, either with or without rotations. A rotation in and of itself has not been sufficient to maintain the acre-yields of such crops as beets and potatoes. The grain crops have been fairly well maintained, but it is only by supplementing with moderate to liberal applications of farm manure that the highest acre-yields of sugar-beets or potatoes are obtained.

Figure 5—Yield from one-twenty-fifth-acre plats, Central Experimental Farm (Greenville). **Left**: Actual beets from one entire plat heavily manured. **Right**: Actual beets (on box) from an entire plat not manured at all. All other treatments were the same.

Acre-yields well above 20 tons over the last 12 to 15 years have been secured by manuring lands grown constantly to sugar-beets, indicating that on the type of soil existing at North Logan (Greenville), the nutrient elements and the organic matter can be maintained in a condition that will permit satisfactory yields. This, however, is an extremely dangerous practice as pests may become more numerous. In fact, this is already the case on several of the plats, on which it was necessary to abandon constant cropping on account of nematode infestation. Sugar-beets in Utah seem to give greater increases for the manure applied than do most other crops.

The most successful results of all, however, were those obtained from a combination of crop rotation and manuring. When three manurings, under a rotation of alfalfa, potatoes, sugar-beets, peas, and small grains, were applied in each ten years, yields were obtained which were nearly equal to those from plats constantly cropped to beets and given five times as much farm manure. Manurings at the rate of 10 tons yearly for three out of ten years gave 20.3 tons of beets to the acre in this rotation as compared with 21.8 tons obtained under constant cropping when 15 tons of manure were applied for ten consecutive years. In other words, rotation plus 30 tons of manure properly distributed in an 8- or 10-year rotation gave results approximately equal to 150 tons of manure applied in the same period under continuous cropping. While rotations of themselves were not capable of maintaining beet yields, rotation supplemented by manure was able to replace somewhere between 50 and 80 per cent of the manure. In addition to taking this large part in obtaining increased acre-yields, the rotation served as a splendid insurance against pests and diseases, particularly against sugar-beet nematode.

Phosphatic Fertilizer

It has recently become apparent that in many Utah soils the amount of phosphorus available to plants is too low for most successful crop production. Yields had become poor in northeastern Colorado and in eastern Wyoming, and a late rootrot disease, known locally as "blackheart," had become exceedingly prevalent. At first accidentally it was found that the burning of straw on lands greatly increased the yield and overcame almost entirely the late rootrot difficulty. It was found that available phosphorus, liberated from the burning straw, was probably responsible for this beneficial result. By the application of phosphatic fertilizer this same result has since been obtained by one of the large sugar companies in great stretches of its territory. Still more recently, similar increases in acre-yield have been obtained in other parts of Colorado and in sections of Utah and Idaho. As yet, not all soils respond to the application of phosphate. Phosphate deficiency, however, is so widespread that the sugar companies have undertaken a campaign for determining those soils which need phosphatic fertilizers. It is recommended that a small trial be made first and then if results are favorable, to extend the use of phosphate. If laboratory tests were fully reliable this precaution could be omitted, but since they are not always dependable it is better to depend upon field trials and to study their effects rather carefully. It also frequently happens that relatively nearby fields may differ in their fertilizer needs. If a soil, because of its origin or because of its having been long and heavily manured, actually contains a sufficient quantity of available phosphorus, for the immediate present it is uneconomic to add phosphatic fertilizer. Some well-manured soils, however, show a phosphate deficiency of considerable proportions. In other words, the need for phosphorus is rather widely variable and can be determined only by a field trial on a particular farm. Laboratory tests are valuable but should always be followed by field tests before general applications are recommended.

INCREASING ACRE-YIELDS BY CULTURAL PRACTICES

One of the major limiting factors in the success of the sugar-beet industry in the intermountain region is the lack of a sufficient quantity of beets. The quantity of raw products (beet roots) might be increased, in either of two ways: (1) An increase in the acreage of land grown to sugar-beets. It has been pointed out that the advisability of increasing acreage depends on a complicated set of economic conditions. (2) By making better use of the land at his disposal, the capable farmer may increase greatly the amount of beets grown on the same acreages of land. This condition arises largely from the fact that unnecessarily poor stands are annually obtained throughout Utah and in surrounding territory.

Crop Stands

More or less careful field counts have been kept during the last 10 or 12 years by various sugar-beet companies and by the Agronomy Department of the Utah Agricultural Experiment Station. These field data point unmistakably to the fact that, on the average, farmers have only 50 to 60 per cent as many beets on each acre of land as would be obtained if there were no "misses" in the field. The average for several years, involving hundreds of counts in the fields, was approximately a 55 per cent stand.

When beets are somewhat thinner than in the case of a full stand, individual roots become somewhat larger. To determine exactly the increase of individual roots due to extra space would require a detailed and critical experiment. However, this increase has been approximated at from 5 to 10 per cent, which is accurate enough for practical purposes. When a stand of larger individual beets is but 55 per cent, it is quite certain that even this yield will not exceed 65 per cent of what might have been obtained from a full stand. Under field conditions, full stands are a practical impossibility, but where most of the work is done by the farmer himself and where there is an understanding of all cultural practices, 90 per cent stands are possible. It is generally conceded in Utah and southern Idaho that under field conditions, even with contract labor, it is possible to increase the stands from somewhat less than 60 per cent to approximately 80 per cent. Unfavorable seasons tend to lower this figure, but favorable seasons should increase it. This would mean that half of the stands would be somewhat better and half somewhat poorer, but that the average for the entire district would equal 80 per cent.

Just what this might mean is perhaps best understood by repeating that the yields obtained are only from 60 to 65 per cent of what would be procured on the same land if an entire full stand were obtained. Since a perfect stand is too much to expect and since 80 per cent is thought to be a practical figure, there would be an increase from 60 to 80 per cent efficiency in this respect, which is a one-third increase in acre-yield, or about 30 to 35 per cent. As the average yield for Utah is about 11 tons, the gain in acre-yield would be 3 to 3.5 tons without accomplishing anything beyond the increase in stand. In 1927 the Great Western Sugar Company with 10,997 contracts found a close correlation between stand and yield, as is shown in Table 2. The average stand of 60 per cent gave 13 tons to the acre, whereas 80 to 90 per cent stands gave about 16 tons.

In addition to the possibility of improving the stand by a third, it is also deemed possible by proper rotation, manuring, and irrigation practices to increase the yields for a given stand. It is thought that another increase of from 15 to 35 per cent, and perhaps averaging 25 per cent, is possible by proper attention to soil treatment and irrigation. It would seem that it is possible for some farmers to increase their acre-yields to such an extent that the average for large areas would be somewhere from 25 to 50 per cent greater than it is at present. In the territory of the Great Western Sugar

Company in northern Colorado and in western Nebraska, more than half of the increase mentioned has been obtained in the last few years and apparently they are still making further progress. From a purely agricultural standpoint, it would not be difficult perhaps to bring about roughly half of the increases in the suggested acre-yields. The other half would come more slowly and only after more prolonged and more detailed attention had been given to the several phases of cultural practice.

TABLE 2.—RELATION OF PERCENTAGE STAND OF SUGAR-BEETS TO ACRE-YIELD AND TO THE SIZE OF BEETS AS DETERMINED BY THE GREAT WESTERN SUGAR COMPANY FROM ALL THEIR GROWERS IN 1927 *

Percentage Stand Class	No. of Contracts	Average Yield	Average Percentage Stand	Average Weight Beets (Ozs.)
0-19	10	4.55	17.4	32.0
20-29	71	5.44	25.3	26.3
30-39	330	8.12	35.8	27.8
40-49	1267	10.17	45.5	27.4
50-59	3342	12.23	55.2	27.1
60-69	3461	13.60	64.5	25.8
70-79	1799	14.61	73.8	24.3
80-89	563	15.70	83.4	23.1
90-99	126	16.71	93.4	21.9
100	28	18.01	101.0	21.8
Total or Avg.	10997	13.05	60.2	26.6

*Through the Leaves, Vol. 18, No. 5 (May, 1930), p. 191.

GROWING THE CROP

For convenience, the possibilities of increasing acre-yields by attention to growing the crop are discussed under the headings of (1) plowing, (2) seedbed and seeding, (3) cultivation and thinning, and (4) irrigation.

Plowing

Of all tillage operations, plowing is the most expensive and likewise the most important as it furnishes the basis for seedbed preparation, for cultivation, and for irrigation. Good plowing renders subsequent operations both more effective and less expensive, whereas poor plowing renders later operations more costly if it does not make good quality in them impossible. Good plowing consists of turning the soil when the moisture supply makes possible the proper pulverizing of the soil. It is also necessary to turn-under all stubble and other organic matter, including manure. Where soils are distinctly heavy and tend to pack when dry and where there is a great enough supply of winter moisture to permit considerable alternate freezing and thawing, fall plowing is highly recommended. In those regions with practically no winter rainfall, indiscriminate fall plowing is not recommended. As a whole, however, the intermountain region has a fairly good supply of winter rainfall which is usually ample for decomposition of organic matter and for permitting effective alternate freezing and thawing. Manure and stubble plowed under become thoroughly moistened during the winter and early spring in most parts of this region. Even though heavy clods are turned up in autumn they are sufficiently moistened and pulverized by several alternate freezings and thawings. In parts of the Utah sugar-beet territory the winters are frequently dry. From the results of careful investigations conducted in the Sevier Valley and in the Price River area, it has been concluded that this moisture condition may be corrected by proper attention either to fall irrigation or to early spring irrigation. There is no better known way to get a packed clayey or silty soil into a desirable condition of good tilth than to provide a good supply of organic matter and to permit alternate freezing and thawing of the fall-plowed soil. In addition to pulverizing the soil, frost action not only increases the availability of the plant nutrients but also aids in overcoming certain insects. Grasshoppers, for example, are practically eradicated when most of the land in a neighborhood is fall-plowed, provided breeding on nearby waste areas is restricted.

Unusually deep plowing is uneconomic and is not recommended unless increased acre-yields are secured. The most profitable depth of plowing is ordinarily from 5 to 7 inches, although occasionally for such crops as potatoes and sugar-beets an 8- to 10-inch plowing is given. The chief aim is to turn-under all organic material and to get it completely covered. This is accomplished by making the furrow 8 to 9 inches deep, measured on the straight side of the furrow. Many farmers estimate the depth of the furrow on the loose side and think they plow 12 to 14 inches when it actually measures only 8 or 9 inches.

On soils that are extremely loose, spring plowing is sometimes as good as fall plowing, so far as the physical condition of the soil is concerned. Certain sandy soils compact to such an extent, that by seeding-time, fall-plowed land appears not to have been plowed. It is a general practice in several such areas to do all the plowing in spring. Unfortunately, spring plowing year after year permits the accumulation of certain insects; it is possible that some diseases are also spread by this means, though this is not definitely established.

Seedbed and Seeding

Some years ago, the U. S. Department of Agriculture made a careful survey at Lehi and at Garland, Utah, and at Idaho Falls, Idaho, regarding the causes of poor stands in beets. This study showed that there was an average stand of only 52 per cent; it also indicated that 19.3 per cent of the stand was lost due to coarse or loose seedbeds and due to poor drilling. There was a loss of 21.4 per cent during thinning and the cultivations immediately before and after thinning. The losses due to the later cultivations, to irrigation, and to other unnamed causes amounted to only 7.3 per cent. During the period of the study, therefore, heavy losses were caused by (1) poor seedbed preparation and drilling and (2) poor thinning and cultivating.

The chief difficulty with seedbeds was that they were either too coarse or too loose. Partially rotted weeds, stubble, or manure were too frequently found on the surface of the land at the time drilling was begun.

There are many instances of poor drilling where one of the drills has missed seeding—sometimes for a few feet, sometimes for a few rods, and in a few cases for the entire length of the field. This inability to properly drill the seed has resulted from one of three causes: (1) The drill may have been in poor working condition; (2) the drill may have become clogged which was not discovered immediately; and (3) rubbish in the soil may have collected in front of the drill shoe. This poor drilling, plus the poor condition of the seedbed, has permitted the loss of practically one-fifth of the stand before the beets had had any opportunity to grow. Probably three-fourths of this difficulty might have been readily overcome.

Cultivation

The land should be plowed as early as possible in order to permit natural packing. Fall plowing is recommended; where fall plowing is not possible, spring plowing should be as early as possible. Time is essential both for soil packing and for the initial stages of decomposition of organic matter. As soon as the surface soil is dry enough, top-working may begin. It has frequently been observed that at least in Utah where spring rains may stop suddenly, care should be taken to preserve as much as possible of the surface moisture. Frequently, heavy disking permits the loss of moisture out of the 3 or 4 inches of surface soil and, if followed immediately by a dry spring this may never be restored. Obtaining good stands on dry, loose seedbeds is extremely difficult. Therefore, in most cases it is best either to disk lightly or to work-down the seedbed with the spiketooth harrow and drag. In normally wet springs there will be sufficient rain to wet down a smooth, dry, disked mulch; however, Utah is an arid region and frequently the spring rains do not come for two or three or more critical weeks. Poor stands of beets and of other fine-seeded crops may result unless utmost precaution is taken to preserve the moisture in the seedbed by shallow working at the surface, preferably with a spike-tooth harrow.

Frequently the seedbed is not firmed sufficiently. In ordinary cases a seedbed on which horses can walk and sink no more than half the depth of their hoofs or even less is not too firm. A seedbed in which horses sink to the fetlocks is far too loose to preserve moisture near enough to the surface.

It is probably best to use the spiketooth harrow, as the last tillage implement on the seedbed. This leaves a slight mulch, thereby preventing the formation of a crust. Some growers are particularly careful to have this last harrowing go cross-wise to the drilling as it is then possible to see more clearly the marks of the drill.

Seeding

In drilling, not only should attention be given to the condition of the drill and to the seeding operation itself, but also drilling in rows as straight as possible. Straight rows greatly reduce the cutting out of beets during cultivations that immediately precede and follow thinning. The cultivator teeth also get closer to the rows, thereby reducing the area left for hand-weeding. Four essentials for a properly drilled beet field are: (1) A fine, mellow, well-leveled seedbed, (2) a good beet drill, (3) a good team, and (4) an alert and skillful driver. Lacking any one of these essentials, it may be profitable for the grower to hire help, if it will assist in perfecting the combination.

Plenty of beet seed should be sown. It is false economy to seed 10 or 12 pounds when 16 to 20 pounds would insure a better stand. Under present circumstances it is probably more economical for the factories to continue their practice of providing the seed; however, growers may find it profitable to take a more active interest in the best varieties of seeds to plant. For safety continuous experiments regarding all varieties of crops are necessary. It is also well to remember that a variety superior in one locality is not necessarily so in a neighboring one where conditions are slightly different.

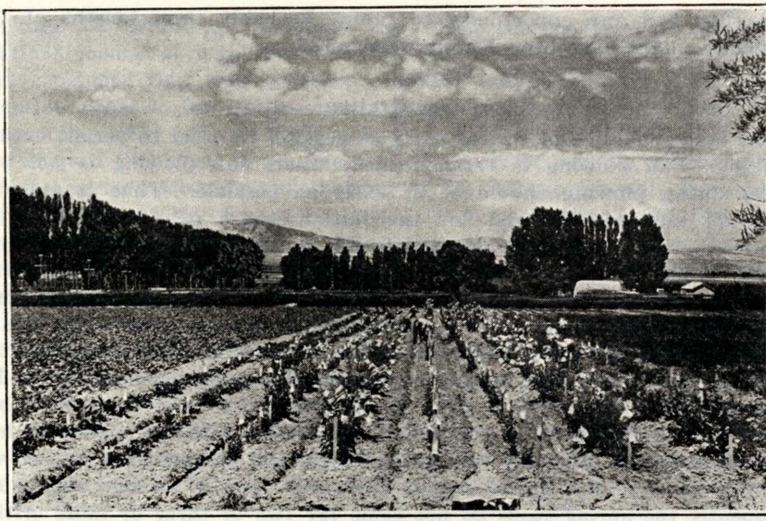

Figure 6—View of sugar-beet breeding plats, North Logan. It is necessary to grow sugar-beet seeds under bags in order to prevent crossing. An attempt is being made to improve the yield and quality of sugar-beets and to obtain resistant strains to leafhopper.

CULTIVATION AND THINNING

As thinning time approaches the usual practice is to cultivate once or twice before thinning; in case more than one cultivation is given it should be as close to the beet row as is possible without covering the beets. Thinning then follows as rapidly as circumstances warrant. It has been clearly demonstrated over and over again that the sooner healthy beets are thinned after they are ready the higher the yields. A difference of three weeks will sometimes make a difference in acre-yield of 2 to 4 tons or even more.

Sometimes young beets suffer from "black root," or seedling rootrot, or "damping-off," as any one of several diseases is called. This trouble can be detected in the field by pulling a few handfuls of beets here and there to see if the roots are white and clean or if many of them are darkened and injured. In case a rather large proportion of the beets show seedling rootrot, it may be best to delay thinning for some days, as ordinarily all beets which will take the disease do so in a comparatively short time. In wet weather and on soils that are somewhat moist, this disease may become rather serious. It usually helps if the land is well-drained and if the soil is loosened near the beets to permit it to dry out rather readily. Since this trouble fortunately is not serious in Utah, except in certain local areas, thinning may usually progress as rapidly as possible.

Care in Thinning Important

It has been demonstrated that where it is possible to leave beets that are somewhat larger than ordinary, this practice likewise increases the acre-yield 1 to 3 or even 4 tons. Good thinning, which is of outstanding importance, consists of leaving beets in an uninjured condition at regular intervals of about 1 foot from the center of one beet to the center of the beet on either side. Perhaps it is safest to say that there should be about 100 beets in every 100 feet of a row. Soils vary slightly as to the spacing that is best, but this variation has been found to be much less than growers have realized. A study of this condition has revealed that the variation ranges from 10 inches to 14 inches. There have been almost no cases in which there was not a decrease in yield when the beets were spaced much wider than 12 inches.

If a grower fully realized that the most profitable way in which he could spend his time during beet-thinning is personally to supervise thinning operations, he would give it more attention. Some fairly careful observations indicate that with 12 or 15 boys or men thinning his beets, it is worth $50 to $60 a day for a grower to be in the field, checking on both spacing and quality of thinning. He should move about constantly, seeing that the work is properly done, rather than attempt to do any thinning himself.

As long as thinning is done on a contract basis, with the emphasis so placed that the thinner gets a larger income from a larger area thinned rather than from a somewhat smaller area more carefully thinned, poor work will continue. Growers' organizations should bend every effort to devise contracts which will make it profitable for the thinner to do good work as opposed to a larger area covered but somewhat carelessly done.

When field stands of beets are high and when seedbeds are in good condition, thinning costs may be reduced considerably by mechanically blocking the beets. This is ordinarily done by cultivating at right angles to the row with a beet cultivator on which the knives or duckfeet are so attached as to leave 2- to 4-inch blocks of beets. The thinner, with only 2 to 4 inches of row left in each foot, can do the work in about two-thirds to three-fourths the time required for full rows. He can also pay more attention to leaving the larger beets and can come more nearly to leaving a beet for each foot of row. Poor stands and rough seedbeds are not favorable for mechanical blocking. In most years more careful preparation of the seedbed and the drilling of somewhat more seed to insure fuller stands might make mechanical blocking possible. Mechanical blocking also loosens the soil and kills the weeds more thoroughly than is possible by hand.

That cultivation which immediately follows thinning also deserves the utmost care on the part of the grower. At this time it is much more serious for a few beets to be cut out; once they are gone there is no practical method of replacing them. Good cultivators, good drivers, a mellow seedbed, and careful supervision cannot be too strongly emphasized. It seems reasonable, in view of the accomplishments in some areas already mentioned, that if farmers were properly educated to their own interests, the loss in thinning could be reduced to half of what it now is. In other words, there seems to be no insurmountable difficulty in holding the thinning loss to about 10 per cent.

IRRIGATION

About 80 per cent of the entire beet crop must be irrigated, one-half of which perhaps is grown in sections where there is an inadequate water-supply during all or during part of some seasons. The beet-growing areas in the Snake River Valley and in the eastern foothills of the Rocky Mountains on the whole are supplied with irrigation water from reservoirs of such magnitude that there is ordinarily no water shortage. In the intermountain territory, however, there is still much dependence on the annual winter snowfall on small mountain watersheds. In 1924 and again in 1926 the snowfall was only about 50 to 60 per cent normal and the succeeding crops were extremely poor, due in part to lack of irrigation water and in part to leaf-hopper and rootrot injury which seemed to be somewhat related to the mild preceding winters.

Careful studies were made in Cache Valley in 1926, particularly on the plats of the Experimental Farm at North Logan (Greenville). These studies brought out the fact that liberal manuring with farm manure, such as would maintain the organic matter and thereby help preserve soil moisture in the seedbeds, gave especially good stands, while soils that were too loose or had become too dry, suffered immediately. On poorly prepared seedbeds, the stands were only about 50 per cent. Poor stands were also obtained on soils that were not irrigated soon enough to help the young beets develop.

Early Irrigation Often Profitable

One of the important principles in the intermountain region is to take special precautions to see that young beets are not allowed to suffer for water early in the season. Sometimes at a depth of 6 inches the subsoil may be well supplied, but due to a sudden spell of dry weather the surface may lose its moisture and the beet roots be unable to penetrate this dry top layer. Plants cannot possibly penetrate a soil if their roots cannot obtain water. It is important, therefore, to provide enough water to connect with the subsoil moisture. Usually the proper method is to give light irrigations placed as close to the beets as is reasonably possible.

Irrigations heavy enough to swamp the plowed surface of the soil might be injurious, especially if the water is unduly cold. Since there is no real need of supplying more water than is necessary to connect with the moist subsoil, growers will find it distinctly to their advantage to apply light irrigations early enough to make certain that there is no cessation of growth in young beets. This seems to be a critical period in the life of young beets as the season is short at best; if a few days or two weeks are lost in spring, in addition to obtaining a poor stand, individual beets are much smaller. It has also been demonstrated that more careful irrigation will do much to overcome epidemics of late rootrot which may get started at this period, because too great a delay in irrigation weakens the beets.

In rainy seasons such as occurred in 1925, this early partial spring irrigation is usually unnecessary, although ten years' observation seems to indicate that in more than half the years light early irrigations are profitable. Sometimes beets should be irrigated before they are thinned, and occasionally in some localities the seedbed should be irrigated before seeding or immediately after.

Size and Frequency of Application

After the roots have extended into the subsoil, as they do in the first three or four weeks, ordinarily they can subsist upon the stored moisture for some time. However, there are conditions when the subsoil itself is depleted of water, in which case irrigation needs to be early enough and heavy enough to wet down considerably. In northern Utah and in similar territory, irrigation, except in extremely dry springs, is not necessary until after that cultivation which follows thinning. In dry seasons partial early irrigation, already discussed, will probably carry the beets over to about the same period or perhaps a little later.

The first major irrigation should be applied before the beets show much wilting. It is always safe to irrigate a little too early rather than a little too late. An old idea, not substantiated by experimental evidence, was that withholding irrigation caused beets to send their roots into the subsoil after deeper water. Where this practice of delaying irrigation has been followed, the results have usually been unsatisfactory because roots can develop properly only under conditions of medium moisture supply.

Since fine-grained soils usually hold considerably more water than porous ones, the amount of water to be applied in a single irrigation is greater on loamy and clayey soils than on sandy and gravelly types. A farmer who has handled his land for some years knows how to irrigate in order to get the water deep into the soil. Sometimes it is necesary to irrigate slowly and for several hours in order to permit penetration. Sometimes, on extremely porous soils, the land is saturated almost as soon as the water reaches the bottom of the field. Proper manuring, fall plowing, and good rotations tend to avoid the undesirable features of both of these extremes and to bring about in the soil the desirable medium condition. On moderate to heavy deep loam soils, a good irrigation is ordinarily 4 to 6 inches, which takes several hours to soak into the soil and which should be applied every 12 to 20 days. On more porous or more shallow soils, 2- to 4-inch irrigations are about all the soil can retain without either deep percolation or partly swamping the land. When smaller quantities are applied it is usually necessary to apply them at more frequent intervals, such as 8 to 12 days. Under certain conditions it has been found that weekly irrigations give beneficial results, but such frequency of application naturally involves a greater labor cost in applying the water.

Subsequent irrigations follow at more or less regular intervals throughout the season. The important thing is to maintain an intermediate condition of soil moisture, never allowing it to become over-dry and, if possible, to avoid its becoming over-wet. As autumn approaches and the beets become full-sized, it is usually necessary to get the water deep into the soil; under favorable conditions, the roots are 4 or 5 feet deep by this time, and it is desirable to have the entire root zone at work. There was formerly a tendency to discontinue irrigation considerably before harvest in order that the soil might become rather dry. For several years it has been well understood by factory operators that it is advantageous to have the beets come to the factory fresh and unwilted in order that crisp cossettes and clean cutting might be accomplished. This is also an advantage to the grower as the moisture content of the beet is retained, thereby increasing tonnage somewhat. It is also easier to dig beets from moderately moist than from firm, dry soil.

PESTS

There are three major pests in the intermountain region which seriously injure beets: (1) leafhoppers, (2) nematodes, and (3) weeds.

The Leafhopper

The sugar-beet leafhopper, or "white fly," is a regional problem only, as this insect is not a pest east of the main chain of the Rocky Mountains although it occurs as far east and as far south as Florida. Careful studies have established the fact that it is practically impossible to do anything of consequence in fighting the leafhopper itself. Once the curly-top disease is contracted, it seems almost impossible to improve conditions. There are two general methods, however, by which the injury may be appreciably reduced.

In the first place, if rotations, manuring, and seedbed preparation promote a rapid and vigorous growth in the beet, the beet itself will do considerable toward reaching a fairly good size before leafhopper attacks occur. In parts of the Pacific Coast section it has been found that beets seeded in January or in February may largely escape the ravages of the leafhopper, as the beets are probably half-grown before they are attacked. In the intermountain region such early planting as this is not possible, but the grower eventually should make preparations which will permit sowing at the earliest possible safe time. Some years ago seeding sugar-beets earlier than some two or three weeks after small grain was sown was unheard of. In many sections, practical growers now prepare their seedbed in the fall, except for a little harrowing, and drill beets at the same time or sometimes a little earlier than they do wheat, oats, or barley. If there is a late infestation of leafhopper the beets will probably be large enough to escape with only partial injury. When there is no leafhopper attack, the yield is larger because of this early seeding. Occasionally, even this early seeding does not permit the beets to get through the season without some damage from curly-top, as the insects may appear in the fields when the earliest beets are still small.

Meanwhile, there is a rather intensive campaign for producing a sugar-beet which is resistant to the curly-top disease. Certain strains have already been obtained by the U. S. Department of Agriculture and by some of the state agricultural experiment stations. It apparently will take several years to get strains that can be depended on and that will be available in commercial quantities. This work, however, needs to be prosecuted with all vigor possible. A plant-pathological attack combined with a plant-breeding attack should produce satisfactory results in a relatively few years. A combination of the working principles of both methods is highly necessary to full and early success.

Whether the present accomplishments are merely preliminary or whether the major part of the work has already been done remains to be seen. It would seem that a long and tedious campaign will be required before it can be said that this pest is successfully combated, unless a more concerted attack is organized. In parts of the region west of the Rock Mountains it is not at all assured that curly-top and other pests, as well as certain other factors, will not succeed in eliminating the sugar-beet industry before plant-breeding and other scientific methods can produce a practical solution.

The Sugar-beet Nematode

The sugar-beet nematode has long been a serious pest in Europe, completely destroying the industry in some localities. Since in the early days of the industry in the United States there was little nematode-infested land, high yields were produced on lands which in the next few years became infested and had to be devoted to other crops. Fortunately, there is now available a method of overcoming the most serious injury of this pest, and which will at the same time maintain a good sugar-beet acreage. This method is a good crop rotation.

Careful experiments, conducted largely by Thorne[4] of the U. S. Department of Agriculture in this region and corroborated by observations on the part of various sugar companies and by the Department of Agronomy, Utah

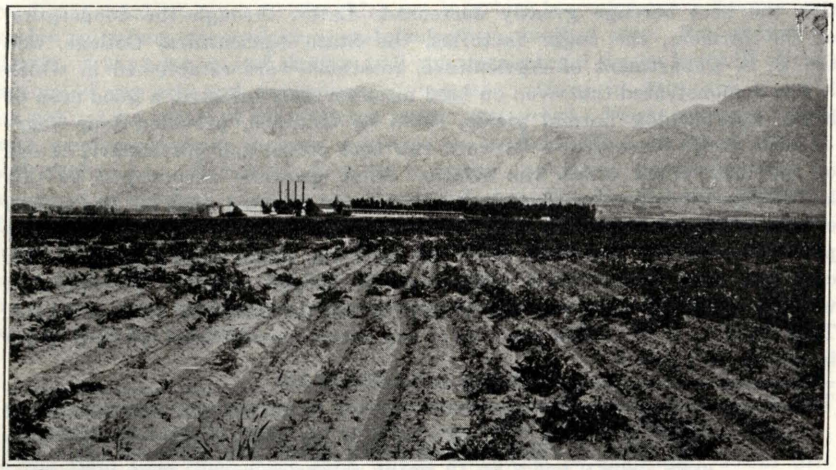

Figure 7—Growth and stand of beets grown continuously on land heavily infested with sugar-beet nematode. Compare with Figure 8.

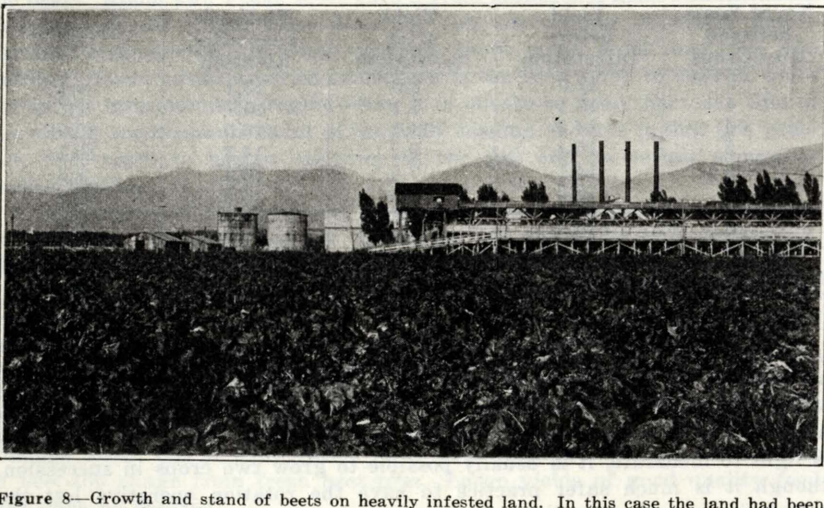

Figure 8—Growth and stand of beets on heavily infested land. In this case the land had been rotated to other crops just previous to the crop of beets here shown. Compare with Figure 7.

[4]Thorne, Gerald. "The Sugar-beet Nematode in the Western States." U. S. D. A. Farmers' Bul. 1248 (1922).
Thorne, Gerald. "Length of Dormancy Period of the Sugar-beet Nematode in Utah." U. S. D. A. Dept. Cir. 262 (1923).
Thorne, Gerald. "Control of Sugar-beet Nematode by Crop Rotation." U. S. D. A. Farmers' Bul. 1514 (1926).

Agricultural Experiment Station, have made clear the fact that even on land once heavily infested with nematode, good crops of beets may be produced at least once in five years, provided proper rotation, fertilization, and good cultural practices are maintained. Heavily-infested land produces low yields, even when best cultural practices are followed. At Lewiston, Utah, at the north end of Cache Valley, for example, where there was a heavy infestation the beet acreage greatly decreased. Later, through the cooperation of the farmers, the sugar factories, the State Agricultural College, and the U. S. Department of Agriculture, rotations were established in which it was demonstrated that even on land most severely infested, a good crop of beets, approaching normal yields, could be obtained, provided four years of other crops were grown between two beet crops, and particularly if one of the intervening crops was alfalfa. Some growers, encouraged by this knowledge, attempted to grow beets on heavily infested land for the second or third year but usually met with disastrous results as the nematode population quickly increased when the land was again seeded to beets. No case has been found where four years of proper rotation intervened in which a good beet crop was not secured so far as nematode was concerned. That neither six to twelve years gave any better control than did four years is shown in Table 3.

TABLE 3.—ACRE-YIELD OF SUGAR-BEETS BEFORE LAND BECAME INFESTED WITH NEMATODE, THE YIELD ON SAME LAND AFTER IT BECAME INFESTED, AND YIELD OF FIRST CROP OF BEETS AFTER THIS INFESTED LAND HAD BEEN GROWN FOR 3 TO 12 YEARS TO OTHER CROPS. THE YIELDS ARE ALSO GIVEN WHEN THE SECOND CROP IN SUCCESSION WAS GROWN AFTER HAVING ROTATED THE LAND. (DATA ADAPTED FROM THORNE, U. S. DEPT. AGR.*)

No. of Years between Beet Crops	Yield before Infestation	Yield after Infestation	Yield 1st Year after Rotation	Rotation 2nd Year
3	12.0	8.3	13.1	9.1
4	16.1	7.1	15.7	6.7
4	14.2	11.4	16.0	10.9
5	15.4	9.2	14.3	10.1
5	14.1	7.5	13.2	8.6
6	16.3	10.9	18.5	15.2
7	18.0	7.5	15.2	9.6
12	18.0	7.7	17.1	9.4

*Stewart, G. and Bateman, A. H. "Field Studies of Sugar-beet Nematode." Utah Agr. Exp. Sta. Bul. 195, p. 28 (1926). (See Footnote 4.)

It is possible, therefore, to grow 20 per cent of the land in beets each year even under the heaviest infestations and to obtain yields approximately as large as the land produced before there was any infestation. The temptation to grow two or three crops in succession must be avoided as the yields are likely to be much reduced after one crop is grown. When the infestation is light to moderate, it is usually possible to grow two crops in succession, though it is much safer practice to have the rotation operative lest the infestation change from light to heavy at any time. It seems likely, though not as yet definitely proved, that where rotations are in general practice, one intervening period of four years and another of two years would probably serve to obtain good crops of beets. This is a practice that is widely advocated in the sugar-beet territory of northern Colorado and western Nebraska.

Weeds

Weeds use plant nutrients and soil moisture that should be left for the beets. Once land is infested, constant cultivation and hoeing are required for proper control. Indirect control, however, is much more effective and is also less expensive. Most effective of all methods of weed control is a good crop rotation, since weeds which are injurious in one crop are frequently unable to endure the ordinary treatment given another crop. For example, alfalfa, if kept young and thrifty, will suppress annual weeds but will allow cultivated grasses and dandelions to increase. These in turn are almost automatically removed by ordinary cultivated crops. Feeds contaminated with weed seeds make manure a dangerous carrier. When banks of canals and ditches are allowed to grow up to weeds, irrigation water becomes a means of infestation. Low-grade farm seeds are likewise common carriers. The great control agencies of weeds, therefore, are **good crop rotations, clean feeds and clean bedding for animals, weed-free ditch and canal banks, and clean seed.** The farmer should spare no effort nor labor expense to free his farm land from weeds after which clean farming and good rotations should be consistently practiced.

HARVESTING BEETS

Since the growing season in Utah is somewhat shorter than is conducive to the highest possible returns, it is necessary to allow the beets to remain in the field somewhat later than might otherwise be desirable. From the standpoint of beet growers, a frost late in September or early in October is probably beneficial; it apparently causes sugar to form more readily in the beets. About two weeks after such a frost occurs is a good time at which to begin harvest if the delay does not risk the coming of winter before harvest is completed. In some seasons, there is no frost until far into October. There comes a period sometimes in the first 10 or 15 days of October in the intermountain region when it is unsafe to delay harvest. One of the strong arguments in favor of the early seeding of beets is that this practice does much to hasten maturity in the fall and to permit somewhat earlier digging.

A fair degree of soil moisture, as discussed under irrigation, is desirable at this time. Although harvest operations are generally well understood, there are certain losses at this time which can readily be overcome.

During sugar-beet harvest the farmer has two major opportunities for increasing his income from the beet crop. No great amount of extra labor is entailed in either case, and yet the profits are written in large figures. To neglect getting the most from beets at harvest time after a toilsome and expensive production seems wasteful. Growers are urged to give full consideration to these two phases of beet harvest: (1) The prevention of tonnage losses due to evaporation or to poor topping; and (2) the making of beet-top silage from fresh beet tops. Large yields of good quality feed may thus be secured.

Beet-top Pasture and Silage

Pasturing beet-tops is a common practice and one which furnishes a considerable amount of feed. The ordinary method of leaving the tops on the land partly covered with dirt causes heavy losses in feed constituents. Pasturing is wasteful and somewhat dangerous, for the tops soon begin to decay when partly covered with moist soil or even when left on the surface of the ground. Many animals are affected by eating decayed tops. In picking up the tops, animals are certain to get some dirt which has been found to be dangerous to horses, especially to colts. This trouble and most of the losses in feeding value can be avoided by making silage of the fresh beet-tops, if this is possible. If not, pasturing is probably next best.

Farmers who plan to make beet-top silage should prepare a pit in advance of beet digging. A pit 3 to 5 feet deep and just a little wider than is necessary for a wagon to drive through is made on well-drained land in such soil as will not cave. The pit is so shaped that the team and wagon can go in at one end and out at the other.

When the topping of the beets begins, care is exercised to have the tops disposed of in such a way that they can be gathered easily with forks. At 1- or 2-day intervals they are loaded on wagons with pitchforks, with as much dirt as possible shaken out. The wagon is driven into the pit and the beet-tops dumped on about a foot of straw. When about a foot or 15 inches of tops are scattered over the bottom more straw is added, after which is added another layer of beet-tops. When the alternate layers of straw and tops are well-packed by driving over them and by walking along the edges, the air cannot penetrate and little spoilage results. The straw absorbs the juice from the tops and keeps the mass from getting too wet. When the pit is well-rounded above ground, it is sealed (as in the case of a potato pit) with straw and dirt or with beet pulp.

It is highly important to have the tops fresh, to free them from dirt, to pack them well, and to seal the pit thoroughly. Air causes decay, and decayed silage is dangerous.

When fed in limited quantities, with alfalfa hay, good silage is nearly as valuable as alfalfa hay in proportion to its dry weight. It can be cut out of the pit with a hay knife and forked out in blocks.

It is true the tops are valuable for fertilizer when left on the land, but there is nearly as much fertilizing value in the manure and the feed obtained is net gain for the labor.

Beet pulp has proved its high value as one feed constituent in a mixed ration, especially as a succulent which will add variety to an otherwise rather dry ration.

Preventing Losses During Harvest

Several years ago a careful experiment on the losses of weight in beets during harvest was conducted near Ogden, Utah, and at Garden City, Kansas.[5] Untopped beets were weighed and then scattered out on the ground and left for 24 hours. During this period there was a loss in weight of slightly over 10 per cent. The tops give off water rapidly by transpiration. During the first four hours this loss amounted to 7.1 per cent. It pays, therefore, to **top beets at the earliest possible moment after pulling.**

In another trial,[6] topped beets were thrown into small open piles of about 50 to 60 pounds each and into larger piles of 300 to 400 pounds each. Neither was covered with tops. In about seven hours the loss in weight was about 2.5 per cent from the small piles and 1.25 per cent from the larger piles. In 24 hours the loss from the larger piles amounted to almost 5 per cent

[5,6] Stewart, G. "Economy in Harvesting Sugar-beets." Utah Agr. Exp. Sta. Cir. 57, p. 2 (1925).

and in the smaller piles to about twice that much. **It is best to haul beets at the earliest possible time after topping.** When they are left in the field for even a few hours it pays to throw them into rather large piles.

In still a third trial, topped beets were made into piles of about 500 pounds each—half of the piles left uncovered and half of them covered with tops. During five days the piles of uncovered beets lost 15.1 per cent by weight and the covered piles 4.2 per cent. In a repetition of this experiment, the uncovered beets lost 14.1 per cent as compared with 4.8 per cent for the covered. During the first 24 hours of these tests, the uncovered piles lost 3.6 and 2.2 per cent as compared with 0.5 and 0.7 per cent for the covered piles. When beets are to be left in the field for more than a few hours, it is of economic value to cover them well with tops.

Large piles of about 50 tons each lost only 4.1 per cent in the two months of November and December. Beets left in small piles for a much longer time than a week or ten days begin to lose in sugar content by a chemical change called inversion.

Another loss of great seriousness both to the grower and to the factory results from the delivery of poorly topped beets. Beet crowns carry salts which prevent the complete extraction of sugar. Under the present contract the grower suffers about half of this loss and the factory the other half. To leave part of the crown on beets means a loss both to the grower and to the factory.

The factory cannot pay for dirt. To haul beets covered with dirt makes extra hauling for the farmer. The factory must make the tare high enough to cover loss in dirt. The dirt must also be hauled away.

SUMMARY

The sugar-beet industry in Utah increased rapidly from 1916 to 1920 and thereafter decreased to somewhat less than half of its peak production. From 1927 to 1930 Utah devoted about 5 per cent of the farming land to beets, from which the farmers obtained 12 to 15 per cent of their total crop income.

Climate, labor conditions, and the general farming system practiced in Utah are all favorable to successful beet-growing. Bright growing weather, cool nights, and light fall frosts are advantageous. The chief biological handicaps are the sugar-beet nematode and the sugar-beet leafhopper. A crop rotation desirable on general principles largely overcomes nematode injury. All practices which encourage early and vigorous beets lessen appreciably the injury from the leafhopper. Actual solution of the leafhopper problem depends on breeding a strain of sugar-beets resistant to curly-top disease transmitted by the leafhopper. Though this work is well on its way, it will be several years before seed in practical quantities is available.

Among the major concerns of the sugar-beet grower are (1) the proper selection of soils for beets and (2) good soil treatment. Poorly drained, strongly alkaline, compact, or porous soils are to be avoided. On all other soils good acre-yields may be obtained by observing crop rotation, by manuring regularly, and by following good cultural practices. Organic matter from sod and from farm manure furnishes plant nutrients and also increases the water-holding powers of the soil, puts it in a condition of moderate compactness, provides it with better aeration, and supplies food for the soil bacteria.

Farm manure greatly increases the acre-yields but does not of itself afford sufficient protection against such pests as nematode. For this, crop rotation is necessary and is effective, provided four years of other crops (including a legume) intervene between beet crops. On land heavily infested with nematode a full crop may be grown every fifth year. It is unsafe, however, to attempt a second crop of beets in succession. On uninfested land two or three crops of beets may come together. Rotations are much more effective in maintaining soil productivity when farm manure is applied two or three years in 7- to 10-year rotations.

Some soils are low in available phosphorus. On such soils, the application of a phosphatic fertilizer may greatly increase the acre-yields. Since laboratory tests are only partly reliable in determining this need, field tests are highly desirable. These should be on a small scale and carefully checked against untreated adjacent areas. If found profitable on small areas, phosphates may then be recommended on a commercial scale. Tests on one field cannot be relied on for another.

Plowing should be deep enough to turn-under all organic refuse, 8 or 9 inches measured on the straight side of the furrow being a good depth for beets. In regions with enough winter precipitation to wet thoroughly the surface soil layer, fall-plowing is usually highly beneficial except on extremely loose soils which may pack sufficiently by seeding time to have lost the effect of having been plowed the previous autumn. In practically the entire intermountain region medium loams, silt loams, and clay loam soils should be fall-plowed in order to expose them to the alternate freezing and thawing; this pulverizes the clods and renders plant nutrients more available. The soil then packs naturally, thereby eliminating much of the expense involved in making a good seedbed. When spring plowing is practiced it is best done as early as possible.

Fall-plowed land may also be surface-worked the next spring earlier than spring plowing can be done. Sometimes there is no rain after disking and the surface of the seedbed fails to pack properly. Ordinarily it is safer to disk lightly or to omit disking altogether and use the springtooth or the spiketooth harrow. Some of the most successful farmers use only the spiketooth harrow and a drag. By seeding time the seedbed should be so firm that horses will not sink more than an inch or two. Spring-plowed land should not be left unharrowed for more than a few hours as it may dry causing clods to form.

Beet seeding is best done about as early as small grains are sown, in order to have as long a growing season as possible. Constant attention to the condition and to the operation of the drill is profitable. In one study conducted, 19.3 per cent of the stand was lost because of loose, coarse seedbeds and poor drilling. This loss is almost entirely preventable by care in preparing the seedbed and by alertness in drilling. Straight rows reduce subsequent cultivation losses.

During the thinning period, a 20-percent loss of stand often occurs. Care in cultivation, straight rows, and supervision of thinning by the grower are important factors in reducing this loss to 10 per cent or less. Some means should be devised whereby the contract thinner will earn more money for taking extra time and care to leave a good stand then he will for thinning hurriedly a larger area without regard for the stand left. Highest acre-yields are obtained when there are 100 beets to 100 feet of row. This varies much less than is generally thought and is a safe figure for all ordinary soils. The average stand of 55 to 60 per cent with reasonable care could probably be increased to about 80 per cent.

The first irrigation is applied before the beets suffer at all, even before thinning if necessary. Sometimes the surface layer dries out while there is plenty of moisture in the subsoil. In this case a light irrigation should be applied immediately in furrows close to the row. Severe losses occur when young beets suffer for water. Subsequent irrigations are most effective when the subsoil is kept uniformly well moistened but not saturated. On silt loams and clay loams, applications of 4 to 6 inches of water every 12 to 20 days are usually satisfactory when enough soaking time is allowed to get the water 3 or 4 feet into the subsoil. The grower can well afford to make sure of this deep penetration. On porous soils smaller applications applied more frequently give better results. It is often best to use only half-length runs and to crowd the water from one head ditch to the next rather quickly and then to allow enough soaking to make certain that the bottom of the run is wetted to a good depth. Beyond this, soaking porous soils permits heavy seepage losses. The last irrigation may be as late as seems consistent with having the soil damp but not sticky at digging time.

Entire freedom from weeds saves both moisture and plant nutrients for the beets and should be accomplished even at considerable expense. Indirect methods of weed control are most effective. Crop rotation and clean farming generally are the most reliable and the least expensive.

At harvest, beets are best topped at once and either hauled immediately or put in good-sized piles and well covered with tops. Heavy losses, amounting to about 5 per cent in 24 hours for uncovered beets, are thus avoided. The acre-shrinkage from a 20-ton crop of beets left in small, uncovered piles on a warm autumn day in 24 to 36 hours may amount to a ton.

Beet tops are a valuable feed when handled properly. Pasturing the tops is cheap but wasteful. Siloing beet tops in a pit silo with alternating layers of straw and with the whole thoroughly packed and properly covered is a practice often neglected. This source of feed is highly important and deserves the utmost consideration.

(College Series No. 313)

AVAILABLE PUBLICATIONS ON SUGAR-BEETS

Bulletins:

186. Irrigation Experiments in Sugar-beets.
195. Field Studies of Sugar-beet Nematode.
205. The Beet Leafhopper in Utah.
212. Studies on the Morphology of the Beet Leafhopper, **Eutettix tenellus Baker.**

Circulars:

54. The More Important Insects Injurious to the Sugar-beet in Utah.
57. Economy in Harvesting Sugar-beets.
93. Better Sugar-beet Culture for Utah.

Address: Division of Publications,
Utah Agricultural Experiment Station,
Logan, Utah.

TABLE OF CONTENTS